NASA TM X-52682

8p

N65-88833
X63-15668

Code 2A

AEROBALLISTIC RANGE ASSOCIATION

THIRD MEETING

March ~~20 - 21~~ 22-23, 1962

Ames Research Center, NASA
Moffett Field, Calif.

Transcript of a Talk Presented by a Member

of the Ames Research Center Staff

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LIGHT-GAS GUNS [1962] (Conf. Presented at the Symposium to Range Users 3rd Meeting, Moffett Field, Calif., Nov. 27-29, 1962)

The use of light-gas guns to launch models at high velocities for aerodynamic investigations or impact studies now dates approximately 8 years here at Ames Research Center. Two types of guns have been under development during this period. The first of these is the so-called isentropic-compression, or piston-compressed, light-gas gun, as described in NACA TN 4143 by Charters, Denardo, and Rossow in 1957. Some simple modifications to this type of gun, involving the use of a contracting, tapered section in the high-pressure coupling together with a deformable pump piston, have recently led to large gains in performance, as reported this year in NASA TN D-1144 by John S. Curtis. The second type of gun developed during this 8-year period is the so-called two-stage, shock-compression light-gas gun, as described in NASA TN D-307 by Bioletti and Cunningham in 1960.

Currently, there are in use at Ames four two-stage, shock-compression guns and three isentropic-compression, deformable-piston guns capable of launching light plastic models at velocities greater than 20,000 feet per second. The physical characteristics of these guns, and their range of loading conditions, have been tabulated in this first slide. For ease in denoting the various guns, in this and subsequent slides, the guns are designated by the initials of the branch in which they are operated, together with their launch-tube bore size. Note that all these guns are modest in size, with the launch-tube bore diameter in the range between 0.22 and 0.79 inches. Helium is still used in the first stage of the shock-heated guns, where it is shock-compressed by the wave formed by the explosion of a gun-powder charge at the breech end of the stage. However, experience with these guns in recent years has demonstrated that hydrogen is to be used in preference to helium in the second stages of the shock-heated guns

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and in the pump tubes of the isentropic-compression guns, not only from the standpoint of realizing substantial gains in performance but also as a means of alleviating the gun barrel erosion problem. A 1-caliber polyethylene piston is generally used between the helium and hydrogen in the first and second stages of the shock-compressed guns. Polyethylene caps, ranging in length from about 3 to 9 calibers, are also used on or for the pump pistons of the deformable piston guns.

In regard to launch-tube length, we are currently using a minimum length of about 220 calibers for the Hypervelocity Ballistic Range .22-caliber guns, to a maximum length of about 360 calibers for the Supersonic Free Flight .28-caliber gun. It is of interest at this point to note that, with the exception of the largest gun, the HBR .79-caliber-shock-heated gun, all of these guns are now equipped with what we call split-barrel launch tubes, employing a relatively thin-walled tube (clamped between straight, massive sections which are doweled and strongly bolted together) as a liner through which the model is launched. The ranges given for the powder charges and model weights do not necessarily represent the limits to which the guns might be loaded, but rather are only those loadings which have been fired to date.

The maximum performance of these guns has been summarized in the second slide. Note that the abcissa of this plot is given as the projectile weight divided by the cube of the bore diameter of the launch tube. This parameter is proportional to the average density of the models used, and thus permits a rough correlation of the performance of these guns in spite of a fairly wide range in their size. Again it should be emphasized that the performance shown for these guns in this slide does not represent an ultimate limit, but rather is only that maximum performance which has been obtained to date for certain loadings of the guns. In some cases, these loadings are limited by the ability of the model to withstand

the acceleration without breaking up. The highest velocity obtained to date has been 32,400 ft/sec, for a .22-inch-diameter cylinder of polyethylene weighing 0.074 gram. The loss in performance with increasing projectile weight appears to be about the same for all the guns, in spite of a considerable variation in their proportions and in the details of their designs.

In the next four slides I wish to show cross-sections of typical designs for the joint between the high-pressure end of the shock or pump tube and various arrangements of split-barrel launch tubes. All of these designs are currently in use here at Ames. All have performed reasonably successfully, and not too difficult or expensive to manufacture so that, if necessary, the liner may be disposed of after only one round, nor are they difficult or particularly time consuming to maintain.

The first design shown in the third slide, evolved for use with fairly thin-walled tubing liners, say of the order of 0.050-inch wall thickness. The end of the second stage shock tube is shown on the left, the split sections of the barrel are shown on the right, and the two are joined together through the flange by means of an outside ring. The dark sleeve at the center of the cross section is pressed onto the tubing (liner) and then the taper for the scarf-type joint is machined into the end of the tubing before it is clamped in place between the split-barrel sections. The adjoining piece with the matching tapered scarf is made of 17-4PH stainless steel, is highly heat treated, and makes the metal-to-metal seal on the end of the thin-walled liner and keeps it from collapsing inward. On its upstream face are located a mylar diaphragm and O-ring which hold the initial 400 psi pressure of the hydrogen in the second stage.

The next slide shows a design for a somewhat heavier liner, with about 0.080 to 0.100-inch wall thickness. Again the high-pressure end of the pump tube is shown at the left, the split-barrel is at the right, and the two are

joined together by the bolted flange arrangement. In this design, a flanged, heavy-walled cylinder is shrunk onto the end of the liner, after which the end of the liner is faced off and counterbored. The adjacent break-valve holder has a matching cylinder integral with it, which again makes the metal-to-metal seal at the end of the liner when the gun is fired. The small cast-aluminum break valve shown inside the holder has been a very effective device for keeping the pump tube pressures from the model base until the desired "breaking" pressure is reached. Also, the type of O-ring-seal joint shown on the outside diameter of the break-valve holder has been most effective, since it permits some relative axial motion between the gun parts without losing the seal.

The fifth slide shows another arrangement that has performed successfully with a heavy-walled liner. The over-all design is similar to that shown on the preceding slide, except that here only a mylar diaphragm with double-sided scotch tape on each side of it is used as the seal at the joint at the end of the liner.

The last slide illustrates one solution to a problem that has occurred occasionally with the previously shown designs. Sometimes a local swelling of the liner occurs at the joint where the liner leaves the heavy-walled cylinder in which it is shrunk and goes into the split-barrel sections. In this design, that joint is simply placed further down along the liner, where the internal pressures will be lower. Also shown in this slide is still another way the problem of sealing the end of the liner has been solved. Here again the liner is shrunk into a heavy-walled cylinder, the end of which is internally chamfered at about 15°. The liner is then mechanically upset until it fills the chamfer in the cylinder, after which it is faced off, a slight taper (about 10°) is formed as an entrance into the bore, and the corner is rounded. When the gun is fired, the petals of the "petalling break-valve" disc fold back into the liner when the disc ruptures, again forming a metal-to-metal seal at the end of the liner. Mr. Jack Stephenson will discuss the seal used at the outer edge of the petalling disc, and other details of this gun, in the talk which follows.

W128503

LIGHT-GAS GUNS IN USE AT AMES RESEARCH CENTER CAPABLE OF VELOCITIES IN EXCESS OF 20,000 FT. PER SEC.
CALL DIMENSIONS GIVEN IN INCHES, WEIGHTS GIVEN IN GRAMS, PRESSURES GIVEN IN LBS. PER SQ. IN. ABS.)

I. TWO-STAGE, SHOCK-HEATED GUNS

	GEOMETRIC CHARACTERISTICS AND TYPICAL LOADING CONDITIONS											
	FIRST STAGE				SECOND STAGE				LAUNCH TUBE			
* FACILITY	BORE	LENGTH	INITIAL PRESSURE	GAS	BORE	LENGTH	INITIAL PRESSURE	GAS	BORE	LENGTH	POWDER CHARGE	MODEL WEIGHT
AES	1.46	72	400	H_2	79	60	300	H_2	.22	61	30	
HBR	4	96	300		2.25	144	200-250		79	206	500-300	.4
SSFF	.65	38.6	400		.79	62	400		28	130	70-30	.30
SSFF	3	80.5	300		1.5	132	300		50	128	120-500	.1-7

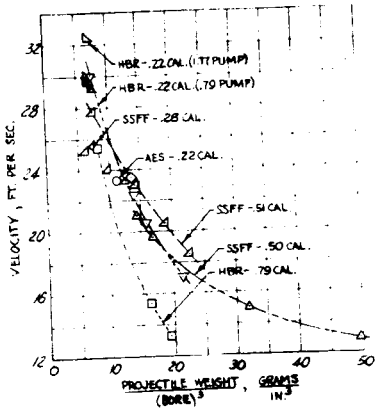
II. ISENTROPIC COMPRESSION, DEFORMABLE PISTON GUNS

	CHARACTERISTICS AND LOADING CONDITIONS							
	PUMP TUBE				LAUNCH TUBE			
* FACILITY	BORE	LENGTH	INITIAL PRESSURE	GAS	BORE	LENGTH	POWDER CHARGE	MODEL WEIGHT
HBR	.79	173	60-75	H_2	.22	48	30-120	.1-.3
HBR	1.77	265	5-30		.22	48	60-100	.07-.15
SSFF	2.13	432	25-40		.51	148	170-200	.8-3.5

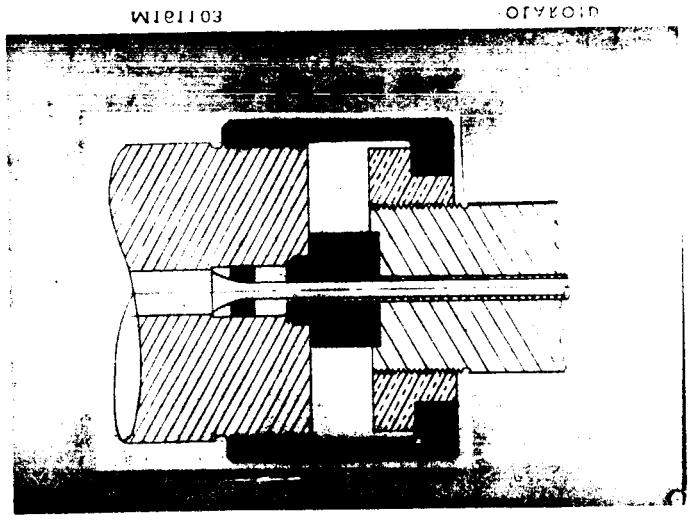
* AES: ATMOSPHERE-ENTRY SIMULATOR
HBR: HYPERVELOCITY BALLISTIC RANGE
SSFF: SUPERSONIC FREE-FLIGHT BALLISTIC RANGE

Slide 1

W128503



Slide 2



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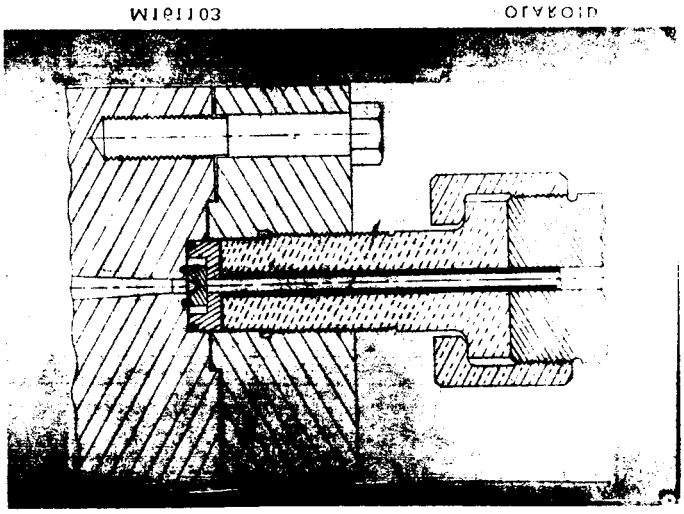

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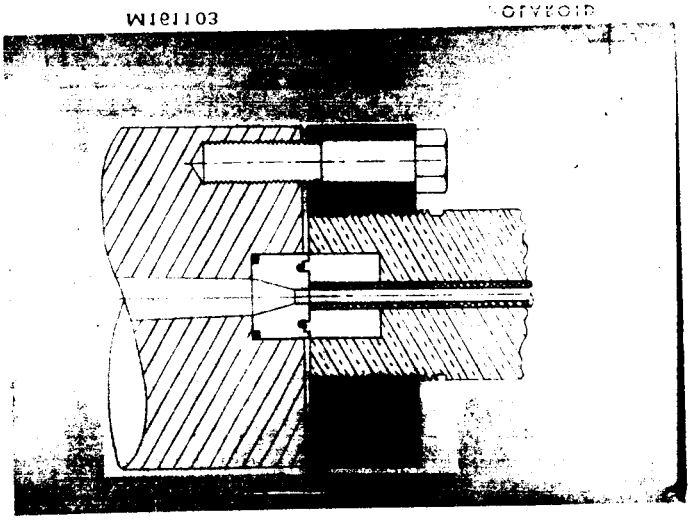

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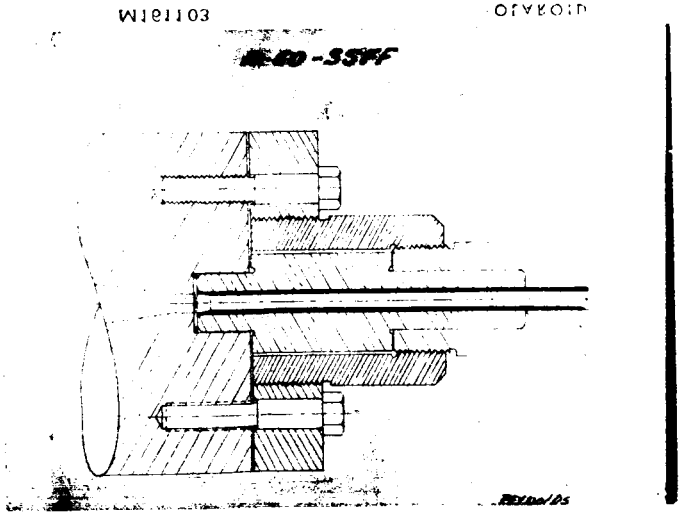

Slide 6